CHAPTER 4 DETERMINATION OF TYPICAL COSTS

4.1 GENERAL

The methodology developed in this study to estimate typical costs provides the user with a fundamental choice between two branches of a decision tree, as previously shown in Figure 1.5.1. If the user selects to go along the upper branch (from the start to A to C, Option 1, or from the start to A to D, Option 2,) then the typical costs for seismic rehabilitation can be obtained by multiplying either four or five terms. Each term represents one or more variables that impact cost and the value of each term is obtained from a table. The validity of the value for each term in each table is a function of the number of original cost data points that exist for the combination of variables that correspond to the term under consideration. For example, Table 4.1.1 shows for Building Group 5 that the original cost data contained no data for the variable combination of low seismicity and the life safety performance objective. In contrast to this, the combination of very high seismicity and the life safety performance objective had 88 original cost data points. Therefore, Options 1 and 2 provide values in tables that are derived using a smoothing of the cost data in the super database to enable values to be filled in the table for all variable combinations, and to provide logical relationships between changes in variables and changes in costs.

The values for each of the terms in Options 1 and 2 are obtained from tables in this chapter. The values provided for the term related to the Performance Objective and Seismicity (denoted C_3 later in this chapter) are obtained by using a statistically based smoothing of the life safety cost data for all buildings. The reason for the use of the cost data for all buildings in this statistical smoothing versus a statistical analysis of the cost data for a single building group was that there was insufficient data to develop a relationship between Building Group/Performance

Objective and Seismicity for each combination of variables. For example, Tables 4.1.1 and 4.1.2 show for Building Groups 5 and 7, respectively, the limited number of cost data points for the different seismicities and performance objectives.

Prior to presenting the three typical cost estimation options in this new methodology, it is important to note a basic finding of the study. It is important to realize that even though one often thinks of buildings as being essentially alike within a basic building class (e.g. concrete shear wall buildings), buildings may have widely different rehabilitation requirements. The results of the work documented in Volume 2 clearly show that if one only uses the results presented in this study to estimate the costs of seismic rehabilitation of a building, the cost estimate will have a very large degree of uncertainty. This uncertainty will exist even if the database includes information on the seismic rehabilitation of several buildings of one building group done in one structural engineering office. Only as the number of buildings of a specific type in an inventory increases in number does the range of cost uncertainty decrease to levels that permit the estimation of costs that are meaningful. It is strongly recommended that if the cost estimate for the seismic rehabilitation of one building is desired, then a structural engineer be employed to perform a structural evaluation and a building specific cost estimate. Volume 2 presents the results of an analysis of the data that provided the basis for this conclusion.

TABLE 4.1.1 NUMBER OF BUILDING GROUP 5 COST DATA POINTS FOR DIFFERENT PERFORMANCE OBJECTIVE/SEISMICITY COMBINATIONS

SEISMICITY	LIFE SAFETY	DAMAGE CONTROL	IMMEDIATE OCCUPANCY
Low	0	1	0
Moderate	15	2	2
High	15	2	2
Very High	88	14	9

TABLE 4.1.2 NUMBER OF BUILDING GROUP 7 COST DATA POINTS FOR DIFFERENT PERFORMANCE OBJECTIVE/SEISMICITY COMBINATIONS

SEISMICITY	LIFE SAFETY	DAMAGE CONTROL	IMMEDIATE OCCUPANCY
Low	2	2	2
Moderate	3	24	5
High	34	17	0
Very High	23	2	16

4.2 OVERVIEW OF METHODOLOGIES

Users desiring to determine typical costs for seismic rehabilitation have different building inventories, objectives and budgets. The methodology that was developed in this study recognized these differences and was developed to allow the user to select a typical cost estimation method from three options. The options vary in complexity and also in their requirements for the amount of information to be drawn from the building inventory. Typically, Option 2 provides a more accurate cost estimate than Option 1 and Option 3 is the most accurate.

Figure 1.5.1 and Table 4.2.1 provide an overview of the options. The methodology presented in Volume 1 is for the calculation of typical costs as defined in Section 1.2, namely, mean structural costs. However, the methodology presented in Volume 2 expands the procedure to enable the user to develop final costs that include such additional issues as architectural, ADA access, etc.

TABLE 4.2.1 STRUCTURAL ESTIMATION OPTIONS

BUILDING INVENTORY INFORMATION	COST ESTIMATION OPTIONS
Building Group Area State Year of Construction Number of Buildings in Inventory	1
Building Group Area State Year of Construction NEHRP Seismic Map Area Performance Objective Number of Buildings in Inventory	2
Building Group Area State Year of Construction NEHRP Seismic Map Area Performance Objective Number of Stories Occupancy Class Occupancy Condition Number of Buildings in Inventory	3

4.3 TYPICAL STRUCTURAL COSTS USING OPTION 1

Figure 4.3.1 shows a schematic of the steps involved in developing a cost estimate using Option 1. Option 1, as noted in Figure 4.3.1. and Table 4.3.1, requires the user to determine the building group, a representative building area (size), the state in which the building is located, the year in which the building will be rehabilitated and the number of buildings in the building inventory.

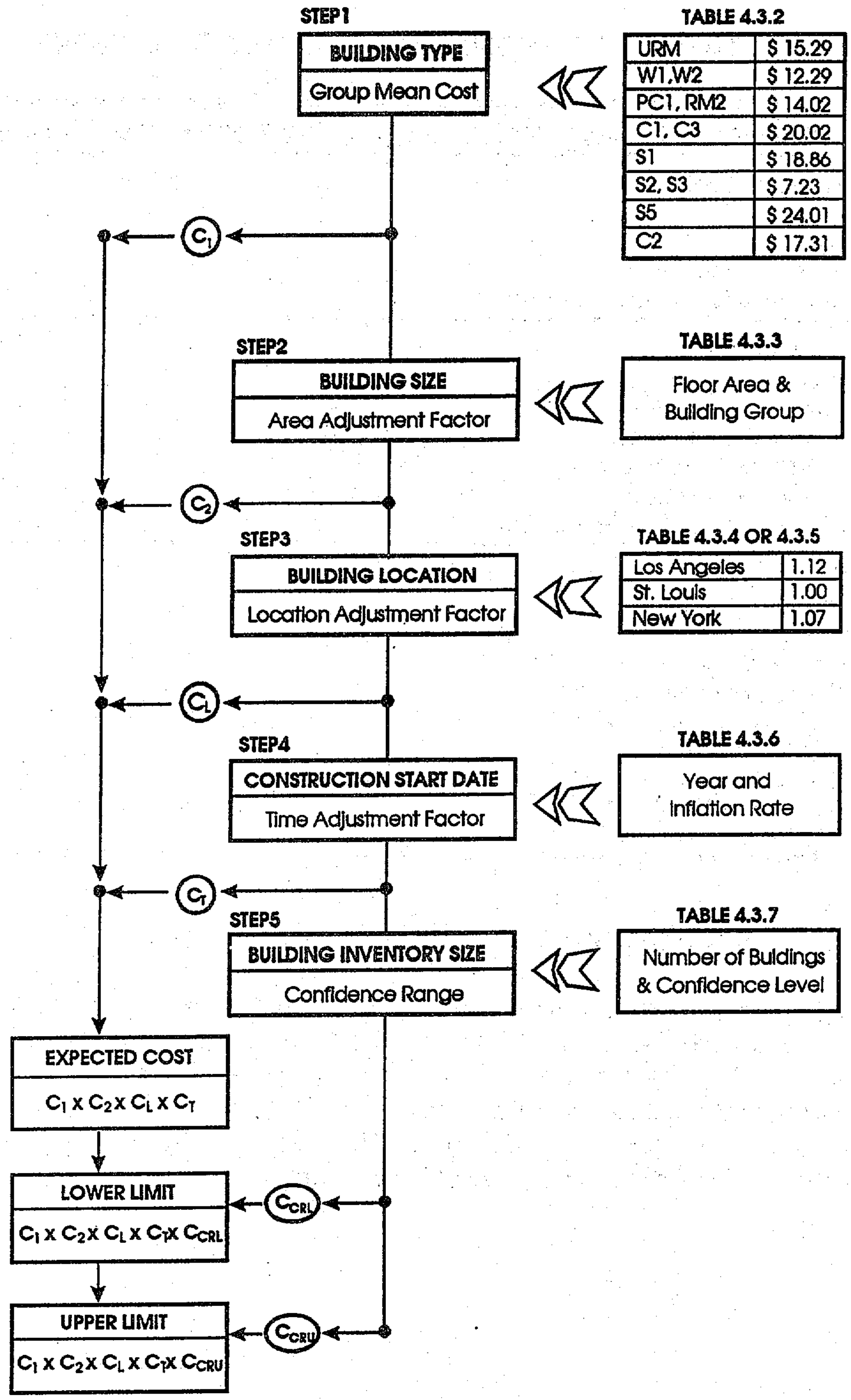

FIGURE: 4.3.1 FLOW CHART FOR COST ESTIMATION OPTION 1

TABLE 4.3.1 OPTION 1 COST ESTIMATION FORM

COST ESTIMATION OPTION 1

1. GROUP MEAN COST

- Group:
  - ☐ URM ☐ S1
  - ☐ W1, W2 ☐ S2, S3
  - ☐ PC1,RM1 ☐ S5
  - ☐ C1, C3 ☐ C2, PC2, RM2, S4
- Cost Coefficient C_1 from Table 4.3.2. | C_1 = $ /sq. ft.

2. AREA ADJUSTMENT FACTOR

- Area
  - ☐ Small
  - ☐ Medium
  - ☐ Large
  - ☐ Very Large
- Cost Adjustment Factor C_2 from Table 4.3.3 | C_2 =

3. LOCATION ADJUSTMENT FACTOR

- City / State ____________________
- Cost Adjustment Factor C_L from Table 4.3.4 or 4.3.5 | C_L =

4. TIME ADJUSTMENT FACTOR

- Year ____________________
- Inflation Rate ______________%
- Cost Adjustment Factor C_T from Table 4.3.6 | C_T =

TYPICAL STRUCTURAL COST
($C = C_1 \times C_2 \times C_L \times C_T$) | C = $ /sq. ft.

5. DESIRED CONFIDENCE LEVEL

- Confidence Percentage:
  ☐ Very Narrow (90%) ☐ Narrow (75%) ☐ Moderate (50%)
- Number of Buildings in Group:
  ☐ 1 ☐ 2 ☐ 5 ☐ 10 ☐ 50 ☐ 100 ☐ 500 ☐ 1000 or more
- Confidence Range Coefficients C_{CRL}, C_{CRU} from Table 4.3.7 | C_{CRL} = | C_{CRU} =

TYPICAL STRUCTURAL COSTS

	Lower Bound = $C \times C_{CRL}$	
	Mean = C	
	Upper Bound = $C \times C_{CRU}$	

The Typical Structural Cost is estimated using the equation:

$$C = C_1 \, C_2 \, C_L \, C_T \qquad (4.3.1)$$

where

C = Typical Structural Cost to Seismically Rehabilitate a Building ($/sq. ft.)
C_1 = Building Group Mean Cost (Table 4.3.2)
C_2 = Area Adjustment Factor (Table 4.3.3)
C_L = Location Adjustment Factor (Table 4.3.4-5)
C_T = Time Adjustment Factor (Table 4.3.6)

Equation (4.3.1) represents, in a statistical sense, a mean estimate of the cost of seismic rehabilitation. This option also provides a confidence interval about this mean that reflects the number of buildings in the inventory and the statistical variation in the cost data.

Each of the steps in the cost calculation shown in Figure 4.3.1 and required for Table 4.3.1 will now be discussed.

- **Step 1 Group Mean Cost**

Option 1 starts with the identification of the building type. From the building type one determines the value of the term C_1, the Building Group Mean Cost, shown in Table 4.3.2. The Building Group Mean Cost is the average or mean cost for all buildings in a group regardless of seismicity or performance objective or any other variables. In the absence of information on seismicity or performance objective, it provides a base for use in the determination of typical costs.

TABLE 4.3.2 GROUP MEAN COST (C_1)

BUILDING GROUP	BUILDING TYPE	GROUP MEAN COST ($/sq. ft.)
1	URM	15.29
2	W1, W2	12.29
3	PC1, RM1	14.02
4	C1, C3	20.02
5	S1	18.86
6	S2, S3	7.23
7	S5	24.01
8	C2, PC2, RM2, S4	17.31

- **Step 2 Area Adjustment Factor**

The next step is the calculation of C_2 which is the Area Adjustment Factor. As noted in Chapter 1 the size (area) of a building affects its typical cost. The category that best represents the building or inventory should be chosen. Inventories that include a wide range of building sizes could be broken up into groups. The building sizes used are defined as follows:

- Small — Less than 10,000 sq. ft.
- Medium — 10,000 to 49,999 sq. ft.
- Large — 50,000 to 99,999 sq. ft.
- Very Large — 100,000 sq. ft. or greater

Table 4.3.3 gives the value of C_2 as a function of the building group and the area of the representative building. As noted in Section 4.1, limited data existed for some building group and floor area combinations. Therefore, the area adjustment factor was computed using linear regression on the data points for each building group. A detailed description of the factor can be found in Volume 2.

TABLE 4.3.3 AREA ADJUSTMENT FACTOR (C_2)

Area (Sq. ft.)	BUILDING GROUP							
	1	2	3	4	5	6	7	8
Small	1.01	0.97	1.13	1.09	1.16	1.18	1.04	1.11
Medium	1.00	1.02	1.07	1.06	1.14	1.12	1.03	1.08
Large	0.95	1.28	0.92	1.01	1.09	0.90	0.99	1.02
Very Large	0.80	1.64	0.57	0.84	0.83	0.51	0.87	0.83

- **Step 3 Location Adjustment Factor**

Table 4.3.4 provides the state by state value for C_L which is the Adjustment Factor for the location of the building. Inventories could be broken up into regions using the average of states in the region. Table 4.3.5 gives values for selected large cities. This factor compares the purchasing power of the dollar in each State with respect to Missouri. It is based on in-depth analysis of the factors affecting the cost of construction in each state, as described in Section 3.3. These factors include the cost of materials and labor. Volume 2 contains a detailed description of this factor.

TABLE 4.3.4 LOCATION ADJUSTMENT FACTOR (C_L)

STATE	LOCATION ADJUSTMENT FACTOR
ALABAMA	0.83
ALASKA	1.25
ARIZONA	0.91
ARKANSAS	0.83
CALIFORNIA	1.12
COLORADO	0.91
CONNECTICUT	1.05
DELAWARE	1.05
DIST. OF COLUMBIA	0.96
FLORIDA	0.86
GEORGIA	0.84
HAWAII	1.21
IDAHO	0.91
ILLINOIS	0.99
INDIANA	0.97
IOWA	0.90
KANSAS	0.86
KENTUCKY	0.88
LOUISIANA	0.85
MAINE	0.88
MARYLAND	0.98
MASSACHUSETTS	1.10
MICHIGAN	0.97
MINNESOTA	0.97
MISSISIPPI	0.80
MISSOURI	1.00
MONTANA	0.90
NEBRASKA	0.84

STATE	LOCATION ADJUSTMENT FACTOR
NEVADA	1.03
NEW HAMPSHIRE	0.94
NEW JERSEY	1.14
NEW MEXICO	0.90
NEW YORK	1.07
NORTH CAROLINA	0.79
NORTH DAKOTA	0.80
OHIO	0.99
OKLAHOMA	0.88
OREGON	0.99
PENNSYLVANIA	1.01
RHODE ISLAND	1.09
SOUTH CAROLINA	0.80
SOUTH DAKOTA	0.80
TENNESSEE	0.86
TEXAS	0.86
UTAH	0.89
VERMONT	0.87
VIRGINIA	0.84
WASHINGTON	1.02
WEST VIRGINIA	0.99
WISCONSIN	0.97
WYOMING	0.86
OTHER: GUAM	0.67

- **Step 4. Time Adjustment Factor**

Table 4.3.6 provides values for C_T which is an adjustment factor that projects costs beyond the 1993 cost database assuming rates of inflation selected by the user. The inflation rate must be selected by the user.

TABLE 4.3.5 LOCATION ADJUSTMENT FACTOR (SELECTED CITIES)

CITY	LOCATION ADJUSTMENT FACTOR
BOSTON	1.10
CHARLESTON	0.80
DENVER	0.91
LOS ANGELES	1.12
MEMPHIS	0.86
NEW YORK	1.07
PORTLAND	0.99
SALT LAKE CITY	0.89
SAN DIEGO	1.12
SAN FRANCISCO	1.12
SEATTLE	1.02
ST. LOUIS	1.00

TABLE 4.3.6 TIME ADJUSTMENT FACTOR (C_T)

YEAR	VALUE OF TIME ADJUSTMENT FACTOR				
	0 %	2 %	4 %	6 %	8 %
1993	1.00	1.00	1.00	1.00	1.00
1994	1.00	1.02	1.04	1.06	1.08
1995	1.00	1.04	1.08	1.12	1.17
1996	1.00	1.06	1.12	1.19	1.26
1997	1.00	1.08	1.17	1.26	1.36
1998	1.00	1.10	1.22	1.34	1.47
1999	1.00	1.13	1.27	1.42	1.59
2000	1.00	1.15	1.32	1.50	1.71
2001	1.00	1.17	1.37	1.59	1.85
2002	1.00	1.20	1.42	1.69	2.00
2003	1.00	1.22	1.48	1.79	2.16
2004	1.00	1.24	1.54	1.90	2.33

It is important to note that instead of Table 4.3.6, the ENR cost index can be used. For example, if this document is used in 1995, the user can look up the ENR index and make an adjustment.

- **Step 5 Confidence Range**

Because every building is unique, the actual cost of rehabilitating any single building will differ from the calculated "Typical Cost" to some degree. In a large inventory of buildings, some actual costs will be lower than the estimate, and some will be higher, so the aggregate actual cost is likely to be close to the estimate. The Second Edition methodology enables the user to determine a range of possible expected cost values as a function of the number of buildings that are included in the typical cost. The user must select the desired range of confidence; the methodology provides the lower and upper bounds on the cost estimate for that confidence level. For example, if a confidence level of 75% is selected, it means that the entire building inventory will be between the lower and upper bounds. The confidence range reflects the uncertainty involved in computing cost values from small data sets. As the number of buildings in the data set increases, the confidence ranges decrease, i.e. the uncertainty surrounding the estimate is reduced. Table 4.3.7 gives the values of C_{CRL} and C_{CRU} which are the lower and upper confidence range adjustment factors.

TABLE 4.3.7 CONFIDENCE LIMITS FOR OPTION 1 COST ESTIMATES

NUMBER OF BUILDINGS	CONFIDENCE LIMITS					
	90%		75%		50%	
	C_{CRL}	C_{CRU}	C_{CRL}	C_{CRU}	C_{CRL}	C_{CRU}
1	0.18	5.57	0.27	3.69	0.40	2.48
2	0.38	2.63	0.51	1.97	0.67	1.49
5	0.54	1.84	0.65	1.53	0.78	1.29
10	0.64	1.54	0.73	1.35	0.84	1.19
50	0.82	1.21	0.87	1.15	0.92	1.08
100	0.87	1.15	0.90	1.10	0.95	1.06
500	0.94	1.06	0.96	1.04	0.96	1.03
1000	0.96	1.04	0.97	1.03	0.98	1.02

4.4 TYPICAL STRUCTURAL COSTS USING OPTION 2

As noted in Figure 1.5.1 and Table 4.2.1, Typical Cost Option 2 requires that the user know the information required to use Option 1 plus the seismicity of the building site, and the performance objective to which the building will be rehabilitated. Table 4.4.1 is the typical cost form for Option 2. A detailed description of Option 2 can be found in Volume 2. The Typical Structural Cost is estimated in Option 2 using the equation

$$C = C_1\ C_2\ C_3\ C_L\ C_T \qquad (4.4.1)$$

where C_1, C_2, C_L, C_T are as defined in Section 4.3 for Equation (4.3.1) and

C_3 = Seismicity/Performance Objective Adjustment Factor

It is important to note that most of the steps in Option 1 are the same as the steps for Option 2. The only additional step is the inclusion of a term to incorporate the influence of the seismicity of the building site and the desired performance objective. The steps in Option 2 are:

- **Step 1 Group Mean Cost**

  Option 2 starts with the identification of the building type. From the building type one determines the value of the term C_1, the Building Group Mean Cost, shown in Table 4.3.2. The Building Group Mean Cost is the average or mean cost for all buildings in a group regardless of seismicity or performance objective or any other variable. In the absence of information on seismicity or performance objectives, it provides a base cost for use in the determination of typical costs.

- **Step 2 Area Adjustment Factor**

  The next step is the calculation of C_2 which is the Area Adjustment Factor. As noted in Chapter 1 the size (area) of a building affects its typical cost. The category that best represents the building or inventory should be chosen. Inventories that include a wide range of building sizes could be broken up into groups. The building sizes used are defined as follows:

  - Small — Less than 10,000 sq. ft.
  - Medium — 10,000 to 49,999 sq. ft.
  - Large — 50,000 to 99,999 sq. ft.
  - Very Large — 100,000 sq. ft. or greater

TABLE 4.4.1 OPTION 2 COST ESTIMATION FORM

COST ESTIMATION OPTION 2

1. GROUP MEAN COST
   - Group:

     ☐ URM ☐ S1
     ☐ W1, W2 ☐ S2, S5
     ☐ PC1,RM1 ☐ S5
     ☐ C1, C3 ☐ C2, PC2, RM2, S4

   - Cost Coefficient C_1 from Table 4.3.2. | C_1 =

2. AREA ADJUSTMENT FACTOR
   - Area

     ☐ Less than 10K sq. ft. ☐ 10K - 50K sq. ft.
     ☐ 50K - 100K sq. ft. ☐ 10K - 50K sq. ft.

   - Cost Adjustment Factor C_2 from Table 4.3.3 | C_2 =

3. SEISMICITY/PERFORMANCE OBJECTIVE FACTOR ADJUSTMENT
   - SEISMICITY

     ☐ Low (NEHRP 1 or 2) ☐ Moderate (NEHRP 3 or 4)
     ☐ High (NEHRP 5 or 6) ☐ Very High (NEHRP 7)

   - PERFORMANCE OBJECTIVE

     ☐ Life Safety ☐ Damage Control ☐ Immediate Occupancy

   - Cost Adjustment Factor C_3 from Table 4.4.2 | C_3 =

4. LOCATION ADJUSTMENT FACTOR
   - City / State ____________________
   - Cost Adjustment Factor C_L from Table 4.3.4 or Table 4.3.5 | C_L =

5. TIME ADJUSTMENT FACTOR
   - Year ____________________
   - Inflation Rate ____________________%
   - Cost Adjustment Factor C_T from Table 4.3.6 | C_T =

TYPICAL STRUCTURAL COST
($C = C_1 \times C_2 \times C_3 \times C_L \times C_T$) | C =

6. CONFIDENCE RANGE
   - Confidence Percentage:

     ☐ Very Narrow (90%) ☐ Narrow (75%) ☐ Moderate (50%)

   - Number of Buildings in Group:

     ☐ 1 ☐ 2 ☐ 5 ☐ 10 ☐ 50 ☐ 100
     ☐ 500 ☐ 1000 or more

   - Confidence Range Coefficients C_{CRL} and C_{CRU} from Table 4.4.3 | C_{CRL} = | C_{CRU} =

TYPICAL STRUCTURAL COST

	Lower Bound = $C \times C_{CRL}$	
	Mean = C	
	Upper Bound = $C \times C_{CRU}$	

Table 4.3.3 gives the value of C_2 as a function of the building group and the area of the building. As noted in Section 4.1, limited data existed for some building group and floor area combinations. Therefore, the area adjustment factor was computed using linear regression on the data points for each building group. A detailed description of the factor can be found in Volume 2.

- **Step 3 Seismicity/Performance Objective Adjustment Factor**

The expected seismic activity of the building site must be quantified in terms of the NEHRP Seismic Area. The user must also decide what seismic performance is desired. The three options are life safety, damage control and immediate occupancy of the building after the earthquake. These objectives are defined in Table 1.2.3 and described in Section 2.6. Table 4.4.2 gives the value of C_3 which is the Seismicity/Performance Objective Adjustment Factor.

TABLE 4.4.2 SEISMICITY/PERFORMANCE OBJECTIVE ADJUSTMENT FACTOR (C_3)

SEISMICITY	PERFORMANCE OBJECTIVE		
	LIFE SAFETY	DAMAGE CONTROL	IMMEDIATE OCCUPANCY
Low	0.61	0.71	1.21
Moderate	0.70	0.85	1.40
High	0.89	1.09	1.69
Very High	1.18	1.43	2.08

- **Step 4 Location Adjustment Factor**

Table 4.3.4 provides the state by state value for C_L which is the Adjustment Factor for the location of the building. Inventories could be broken up into regions using the average of states in the region. Table 4.3.5 gives values for selected large cities. This factor compares the purchasing power of the dollar in each State with respect to Missouri. It is based on in-depth analysis of the factors affecting the cost of construction in each state, as described in Section 3.3. These factors include the cost of materials and labor. Volume 2 contains a detailed description of this factor.

• **Step 5 Time Adjustment Factor**

Table 4.3.6 provides values for C_T which is an adjustment factor that projects costs beyond the 1993 cost database assuming different rates of inflation. The user selects the rate of inflation.

• **Step 6. Confidence Range**

Use Table 4.4.3. The values in Table 4.4.3 indicate confidence limits that are less than those given in Table 4.3.7 in Option 1. This reduction in the limits results from the increased confidence in the estimates that follow from the introduction of the performance objective into the process.

TABLE 4.4.3 CONFIDENCE LIMITS FOR OPTION 2 COST ESTIMATES

NUMBER OF BUILDINGS	CONFIDENCE LIMITS					
	90%		75%		50%	
	C_{CRL}	C_{CRU}	C_{CRL}	C_{CRU}	C_{CRL}	C_{CRU}
1	0.25	4.07	0.34	2.88	0.49	2.06
2	0.44	2.27	0.56	1.77	0.71	1.40
5	0.60	1.68	0.70	1.44	0.81	1.24
10	0.69	1.44	0.77	1.29	0.86	1.16
50	0.85	1.18	0.89	1.12	0.94	1.06
100	0.89	1.12	0.92	1.08	0.95	1.05
500	0.95	1.05	0.96	1.04	0.98	1.02
1000	0.96	1.04	0.97	1.03	0.99	1.01

4.5 TYPICAL STRUCTURAL COSTS USING OPTION 3

Options 1 and 2 were developed in order to enable the user to arrive at a cost estimate using tables. The development of the values in the tables for the various adjustment factors in Cost Equation (4.2.1) or (4.3.1) "smoothed out" local variations based on mathematical averaging techniques and engineering judgement. This smoothing assures the user of having reasonable values of cost estimates even when the actual data for a particular set of inventory values might be small or even zero. In addition, the smoothing process eliminated counterintuitive values derived purely from the database that may have been caused by small inventory values or unrepresentative buildings. Options 1 and 2 are less statistically precise than Option 3. When the typical cost is being determined by a knowledgeable structural engineer who can review the original database and evaluate the results of Option 3 with experience, Option 3 will provide the best statistical estimate of typical costs.

The equation used to calculate the typical cost in Option 3 is:

$$C = C_C\,(\text{Area})^{X1}\,(\#\text{ of Stories})^{X3}\,(\text{Age})^{X2}\ X4\ X5\ X6 \qquad (4.5.1)$$

where

C_C = Statistically based constant.

X1 = Statistically based variable whose value depends on the building group.

X2 = Statistically based variable whose value depends on the building group.

X3 = Statistically based variable whose value depends on the building group.

X4 = Statistically based variable whose value depends on the building seismicity and performance objective and the building group.

X5 = Statistically based variable whose value depends on the building occupancy class and the building group.

X6 = Statistically based variable whose value depends on the occupancy condition during seismic rehabilitation and the building group.

This option is the most statistically rigorous option. The values of the regression parameters were calculated using linear regression on the super database cost data. This produces the most accurate estimate of the cost since all the relevant parameters are included in the analysis. This procedure captures the behavior of the cost data as a function of several factors described in detail in Volume 2 such as the age, the area, the seismicity, the performance objective etc.. The values of C_C and the regression parameters X1 through X6 are given in Table 4.5.1. Table 4.5.3 shows the number of original cost data points that existed for each of the noted combinations. Equation 4.5.1 provides an estimate of the mean value of the typical structural cost. The lower and upper bounds for the typical costs for different confidence levels and for different numbers of buildings in the inventory are given in Table 4.5.4.

Users are urged to employ both Option 2 and Option 3 together and carefully compare the results for consistency. Typical costs determined by Option 3 most accurately represent the contents of the existing database. More information about the proposed rehabilitation is required than with Option 1 and 2 and this information is used to determine a "best fit" cost based solely on a statistically rigorous analysis of the database. However, due to the high variability of rehabilitation costs, even within groups of buildings with similar characteristics, and the inconsistent quantity and quality of data for buildings in the various categories, this option may yield inconsistent to counterintuitive results for some combinations of variables. For example, in certain circumstances, the costs may appear to increase going from higher to lower seismic zones or from higher performance levels to lower ones. As the typical cost database is increased in size and completeness, these inconsistencies should be minimized or disappear, and this option will produce the most representative typical costs with the greatest flexibility in input parameters. Using the currently available database, this option can be useful to experienced evaluators who would incorporate appropriate parameter studies and apply their judgement to the results.

A full discussion of the methodology and assumptions related to this option can be found in Volume 2 of this study.

TABLE 4.5.1 VALUES OF REGRESSION VARIABLES

COEFF.	CATEGORY	BUILDING GROUP							
		1	2	3	4	5	6	7	8
C_c	-	151.9	1.2	13.5	36.9	182.5	137.6	59.2	86.5
X1	-	-0.23	-0.02	-0.26	-0.15	-0.30	-0.11	-0.26	-0.28
X2	-	0.02	0.52	0.60	0.18	0.19	-0.50	0.40	0.14
X3	-	0.28	-0.28	1.06	0.43	0.21	-0.71	0.40	0.53
X4 (See Table 4.5.2 below)	1	0.28	0.48	0.51	0.48	0.53	0.58.	0.47	0.61
	2	2.65	0.61	0.41	2.55	0.46	0.73	1.20	0.64
	3	1.16	0.72	1.25	0.72	1.07	1.27	0.97	0.43
	4	0.57	1.31	0.70	1.03	1.22	0.90	1.74	1.02
	5	0.69	0.40	0.35	0.52	0.76	0.83	0.67	0.44
	6	0.57	0.67	1.03	0.52	0.14	0.30	0.32	2.27
	7	0.76	1.17	0.96	1.01	1.23	0.42	0.81	1.42
	8	2.30	2.53	1.01	1.02	1.30	0.43	1.40	1.61
	9	1.48	1.12	1.20	1.17	1.25	1.35	1.10	1.86
	10	1.28	1.31	1.16	0.62	2.71	3.21	1.25	1.38
	11	1.60	1.24	3.23	1.28	1.89	2.12	1.57	0.46
	12	2.09	1.10	2.15	2.10	1.44	2.36	1.54	1.89
X5	P*	4.27	1.09	1.09	0.26	1.19	1.48	1.15	0.45
	M	0.76	0.43	0.59	4.50	0.45	0.56	0.85	0.36
	R	0.48	0.90	2.19	0.75	2.72	1.11	0.32	1.09
	F	0.98	0.91	0.99	1.03	0.39	0.54	0.96	2.21
	I	0.97	1.35	1.00	0.82	1.29	0.47	1.17	0.96
	C	0.82	0.94	1.47	1.01	0.81	0.73	2.48	1.25
	A	0.83	2.22	.53	1.33	0.91	4.77	1.33	2.16
X6	IP**	0.69	1.78	1.00	0.77	1.11	0.63	0.93	0.69
	TR	1.12	1.13	0.96	1.44	1.28	1.94	1.08	1.21
	V	1.30	0.50	1.04	0.90	0.70	0.81	0.99	1.20

Notes:
*Occupancy Class: See Table 2.6.1
**Occupancy Condition: See Table 2.6.2

TABLE 4.5.2 CATEGORY FOR CONSTANT X4

	PERFORMANCE OBJECTIVES		
SEISMICITY	LIFE SAFETY	DAMAGE CONTROL	IMMEDIATE OCCUPANCY
Low	1	5	9
Moderate	2	6	10
High	3	7	11
Very High	4	8	12

TABLE 4.5.3 NUMBER OF DATA POINTS AVAILABLE IN EACH CELL

COEFF.	CATE-GORY	BUILDING GROUP							
		1	2	3	4	5	6	7	8
X4 (See Table 4.5.2 above)	1	3	0	0	0	0	0	0	3
	2	2	0	4	12	3	0	1	0
	3	42	12	33	48	11	15	14	21
	4	151	16	32	57	14	13	5	90
	5	13	5	3	11	0	0	0	8
	6	42	15	1	32	2	3	17	1
	7	15	34	10	27	2	2	14	26
	8	8	9	10	22	12	7	0	48
	9	4	0	0	2	0	0	0	3
	10	20	0	6	44	2	2	4	0
	11	7	6	10	15	2	4	0	9
	12	0	15	10	27	9	3	6	32
X5	p	1	0	0	11	0	0	0	10
	m	75	1	2	1	0	0	1	5
	r	14	10	3	14	1	1	2	24
	f	43	5	41	23	18	33	5	34
	i	120	78	38	172	23	11	43	104
	c	48	8	25	64	12	3	6	36
	a	6	10	10	12	3	1	4	28
X6	ip	89	10	27	46	13	14	7	29
	tr	160	77	76	198	35	31	48	153
	v	58	25	16	53	9	4	6	5

Notes: The number of data in shaded cells is equal to or less than 4.

TABLE 4.5.4 CONFIDENCE LIMITS FOR OPTION 3 COST ESTIMATES

NUMBER OF BUILDINGS	CONFIDENCE LEVELS					
	90%		75%		50%	
	C_{CRL}	C_{CRU}	C_{CRL}	C_{CRU}	C_{CRL}	C_{CRU}
1	0.34	2.90	0.45	2.21	0.59	1.70
2	0.52	1.91	0.64	1.57	0.77	1.30
5	0.66	1.50	0.75	1.33	0.85	1.18
10	0.75	1.33	0.82	1.22	0.89	1.13
50	0.88	1.13	0.91	1.09	0.95	1.05
100	0.91	1.09	0.94	1.07	0.96	1.04
500	0.96	1.04	0.97	1.03	0.98	1.02
1000	0.97	1.03	0.98	1.02	0.99	1.01